In: J.D. Haywood, ed. Proc. 10th Biennial Southern Silvicultural Research Conf. Southern Research Station Gen. Tech. Rep. SRS-30, 1999.

ECONOMICS OF AFFORESTATION WITH EASTERN COTTONWOOD (*POPULUS DELTOIDES*) ON AGRICULTURAL LAND IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY[1]

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Abstract—Higher prices for hardwood stumpage and changes in agricultural policies may favor afforestation on sites in the Lower Mississippi Alluvial Valley (LMAV) which are suitable for Eastern cottonwood (*Populus deltoides* Bartr.). We examined the potential returns to a landowner growing cottonwood on three soil classes common to the LMAV. We specified the conditions under which we think such afforestation projects will be successful. Afforestation with cottonwood was a profitable investment under most conditions. Including federal cost-share, available under the Conservation Reserve Program (CRP), greatly increased profitability. Landowners interested in establishing oak-dominated forests can offset costs by interplanting cottonwood and red oak. Long-term management for cottonwood pulpwood can be profitable if coppice is included. On lower productivity sites, coppice is probably necessary.

INTRODUCTION

The Lower Mississippi Alluvial Valley LMAV has undergone the greatest conversion of bottomland hardwood forests to agriculture in the United States. Forest clearing occurred as recently as the 1960 and 1970's in response to increasing prices for soybeans (Sternitzke 1976). Today, some land that was cleared is available for afforestation. The Wetlands Reserve Program (WRP) and Conservation Reserve Program (CRP) are two federal programs that provide cost-sharing and easement payments for afforestation. Only the CRP, however, routinely allows planting cottonwood. The economics of cottonwood plantations has changed in the 15 years since Anderson and Krinard (1985). Advances in chemical weed control technology have made it possible to grow stands on heavy clay soils to pulpwood rotations. Nevertheless, landowners must be committed to carrying out the full suite of site preparation and cultural practices to insure establishment of a fully stocked stand.

DATA AND METHODS

The methods for culturing cottonwood considered here are used operationally by Crown Vantage at the Fitler Managed Forest in Issaquena County, Mississippi. These techniques were developed from research (McKnight 1970) and experience. Costs are typical for nonindustrial landowners in the LMAV and based on our experience.

Site Preparation

Afforestation in the LMAV generally occurs on land converted from soybeans. Ideally, site preparation begins immediately following soybean harvest. If soybeans are combined with chopping and shredding, plant residues are a fine debris and pose no problems for afforestation. The first step in site preparation is double discing (discing in two passes, each perpendicular to the other). The cost of $5 per acre per pass only includes operator wages and fuel, as we assume that the landowner is a farmer and already has the needed equipment. Next, the soil is ripped in the planting row with a straight shank to facilitate planting. Cost is estimated at $10 per acre. If a traffic pan has developed, subsoiling must be done in the previous year. The distance between plants within a row (12 ft) is marked by pulling a bar in another pass perpendicular to the planting row. This treatment is necessary to insure uniform spacing within and between rows to allow effective cultivation during the growing season. Marking costs $5 per acre. Nitrogen fertilizer as a liquid is added to the planting slit made by the ripping shank in the same pass. This requires specialized equipment to place the fertilizer 18 to 20 in. deep in the slit. Currently this costs $15 per acre for 80 lbs. of nitrogen. Site preparation should be completed in the fall. On Sharkey (Vertic Haplaquepts) and other expanding clay soils, undergoing several wetting and drying cycles is essential for the slit and drying cycles (from precipitation) in order for fine particles to fill the slit. Otherwise, soil drying in the spring and summer will cause the soil to crack along the planting slit, exposing tree roots to desiccation. These treatments, including fertilization, cost $40 per acre.

Planting

Cottonwood cuttings of 16- to 18-in. lengths are planted by hand from December through March. Espacement for 12 ft by 12 ft results in 302 stems per acre. Improved cuttings are available for approximately $200 per thousand cuttings. Material costs are $60.40, and labor costs are $18 per acre for planting.

Cultural Treatments

Control of competing vegetation is critical during the first growing season because cottonwood is extremely intolerant of shading. A pre-emergent herbicide is sprayed in a 3-ft band centered on the planting row. This should be done over the top of dormant cuttings, between December and mid-February. Chemicals presently used are Goal 2XL, 64 oz per acre and Gramoxone Extra (non-crop label), 32 oz per acre. These chemicals cost $10.88 and $2 per acre, respectively, in 1998-99. Chemicals can be applied in a tank mix with 80-20 nonionic surfactant, 1 percent solution, costing $0.25 per acre. This can applied with ground equipment, such as a rubber-tired, 90 horsepower farm tractor. Readiness to spray is critical, as sufficient dry periods are scarce at this time of year. A banded spray of

[1] Paper presented at the Tenth Biennial Southern Silvicultural Research Conference, Shreveport, LA, February 16-18, 1999.

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Goal at 32 oz per acre ($5.44) is used for emergent broadleaves later in the spring.

Beginning May 1, mechanical competition control begins. A treatment consists of two passes perpendicular to each other. Mowing, discing, and bush hogging are equally effective, and each cost $5 per acre per pass. Two treatments in the first growing season are likely to be needed. As many as four treatments may be required.

Johnson grass (*Sorghum halepense* (L.) Pers.) is a serious competitor and additional steps may be needed for its control. Cottonwood leaf beatle (*Chrysomela scripta* F.) may defoliate young plants and cause mortality. Spot applications for both these pests may be sufficient during the first year, but costs are estimated for banded application. For control of these pests, over the top application of Fusilade (for control of Johnson grass) at 24 oz per acre ($6) and Sevin XLR Plus (for control of cottonwood leaf beatle) at 16 oz per acre ($3.75) is effective. These chemicals can be applied in tank mixture with 80-20 nonionic surfactant at 1 percent ($0.25). With application costs of $5 per pass included, costs of cultural treatments the first year total $63.57.

In the second growing season, mechanical competition control by cross discing will be needed if cottonwood plants are less than 6 ft tall. If cottonwood is greater than 8 ft tall, then discing may be unnecessary. Plants between 6 ft and 8 ft tall may benefit from discing in the second year. Estimated costs for two passes were $10 per acre.

Interplanting

The primary objective in afforestation for many nonindustrial landowners is enhancing wildlife habitat, particularly for game animals and waterfowl (Jones and others, In press). We believe it is possible to accomplish this quickly by interplanting suitable red oak species between every other row of cottonwood (Schweitzer and others 1997, Stanturf and others 1998, Twedt and Portwood 1997). Because mechanical weed control for 1 or 2 years is necessary to establish cottonwood, we delay planting the red oak until the beginning of the third growing season. If height growth of the cottonwood is sufficient the first year, however, oaks can be interplanted at the beginning of the second growing season. Interplanting between every other row of cottonwood allows directional felling of the cottonwood at the end of the pulpwood rotation and avoids damage to the oak seedlings. Because the oak is on a 12 ft by 24 ft spacing (151 stems per acre), labor costs for hand planting are estimated at half that of cottonwood ($18 per acre). Cost of oak seedlings has increased with greater demand in recent years but we estimate that bareroot 1-0 Nuttall oak (*Quercus nuttallii* Palmer) seedlings can be purchased for $0.25 per seedling, thus material costs are $37.75 per acre.

Coppice

For some landowners, allowing harvested stumps to resprout will be advantageous, as a second rotation on the same root system can be obtained for a small investment. Because of multiple sprouting, thinning stumps back to two sprouts in the winter after the third growing season has been customary. Up to 10 sprouts are removed from each stump. Recently, Crown Vantage has harvested every other row in a plantation in the winter, which encourages sprouting. After sprouting has clearly been successful, usually one or two growing seasons, the residual trees are harvested in the summer to discourage resprouting. On small ownerships, this may not be cost effective, so we estimated hand pruning at $32 per acre.

Taxes and Administration

Property tax rates are greater for agricultural than forest land and vary considerably among and within the States in the LMAV. We used estimates provided by Amacher and others (1997): $4.50 for Arkansas, $1.83 for Mississippi, and $1.44 for Louisiana annually per acre. Administration costs were assumed to be $1 per acre annually. We assume timber severance taxes are the responsibility of the timber buyer or harvester.

Cutover

If the landowner's objective is to grow pulpwood through several rotations, greater site preparation costs will be incurred for cutover land than for afforestation of agricultural land. Higher costs will result from shearing stumps close to the ground, piling into windrows, and burning. Site preparation discing with the heavier equipment needed for cutover land is also more expensive. Costs for these operation are $190 for shearing, piling, and burning and $35 per acre for site preparation discing. This allows the necessary mechanical weed control with lighter farm equipment and avoids damage to young plants from flying chunks of wood, as well as damage to cultivators and discs. Subsequent cultural treatments are the same as those previously listed.

Production Data

Yield data for cottonwood plantations are from the Fitler Managed Forest in northwest Mississippi. We selected three stands which represent soils suitable for growing cottonwood but varying in productivity. These stands are all on old field sites, protected by the river levee, with good survival. All were planted with the technology previously described: improved planting stock, fertilized at site preparation, and treated with the new herbicide technology. The stand on the Commerce soil (Aeric Fluvaquents) represents the highest productivity sites. The medium productivity sites are represented by the Tunica-Bowdre soils (Vertic Haplaquepts-Fluvaquentic Hapludolls). The Sharkey soil represents the lowest productivity sites. Stand characteristics are described in detail in Table 1.

Growth and Yield

The best available growth and yield model for plantation cottonwood is that of Cao and Durand (1991). This is a compatible growth and yield model that uses the Sullivan and Clutter (1972) equation form for predicting cubic-foot volume yield and projecting volume from site index, initial age, and basal area. The model was the basis for an Excel spreadsheet called Cotton, prepared by Cao for Crown Vantage in 1994. We used this software to estimate volume to a 3-inch top and yield of green tons per acre for each stand for pulpwood rotations of 10 and 11 years. No model exists for coppice rotations but experience at Fitler suggests that merchantable yield from a coppice is about half that from planting because multiple sprouts result in small, unmerchantable stems. We disregarded any timber value of the interplanted oaks, assuming the landowner's interest would be creating wildlife habitat only.

Prices and Cost Sharing

Stumpage price for cottonwood was centered at $10 per green ton, the average price paid by Crown Vantage. This is higher than the average hardwood stumpage as reported in

Table 1—Characteristics of the stands we selected to represent soil/site productivity classes and their estimated yields at rotations of 10 and 11 years; stands were age 3 years when measured

	Commerce	Tunica-Bowdre	Sharkey
Site Index (base age 10), ft	80	73	66
Basal area, ft^2 per acre	29	17	15
Stems per acre	276	252	260
Survival, percent	91	83	86
Tons per acre, age 10	68.58	50.24	42.05
Cumulative annual increment (green tons per acre), age 10	7.52	6.29	5.36
Mean annual increment (green tons per acre), age 10	6.86	5.02	4.21
Tons per acre, age 11	75.42	56.05	47.01
Cumulative annual increment (green tons per acre), age 11	6.84	5.81	4.96
Mean annual increment (green tons per acre), age 11	6.86	5.1	4.27

Timbermart South but reflects the lower cost of pulping cottonwood as compared to other hardwoods in the process used by Crown Vantage. In our analysis, we varied the value for stumpage at $8, $10, and $12 per green ton.

Afforestation is seldom attractive without the cost-sharing available through the CRP because of the initial capital costs, the lack of an annual return, and greater perceived risk. Although the CRP is federally financed, reimbursement rates and allowable practices are set by individual States. We gathered current information on CRP cost sharing for Mississippi, Louisiana, and Arkansas from their respective State offices of the Natural Resources Conservation Service. They all customarily reimburse a landowner up to 50 percent of establishment costs. Reimbursement rates are summarized in Table 2.

Analyses

Our interest was in both short- and long-term evaluations. For short-term investment analysis, we used Net Present Value (NPV) and Internal Rate of Return (IRR) to compare several scenarios for every combination of soil type (yield) and State (taxes and cost share reimbursement). Our base case assumed a real discount rate of 4 percent (Clutter and others 1992) and no inflation. Internal rate of return was estimated using a 10 percent cost of capital. We examined the impact of rising costs and stumpage by inflating stumpage and costs equally at 3 percent annually, and a scenario where stumpage grew faster than costs (5 percent versus 3 percent). In another set of scenarios, we adjusted for risk by using a discount rate of 8 percent. Analyses were performed using the Project Investment Analysis template available in Lotus 1-2-3- Release 5.

For long-term analyses, we examined three management scenarios which began with afforestation without cost share under the CRP. In the most intensive scenario, the landowner cleared and planted after each rotation. In the moderately intensive scenario, coppice followed afforestation, but thereafter the landowner cleared and planted after each rotation. The least intensive scenario assumed the landowner coppiced for a rotation, then cleared and coppiced. To allow sufficient time for all harvesting and site preparation activities, we assumed a 1-year delay between harvest and replanting. Land expectation value or bare land value (BLV) was derived for each scenario (Clutter and others 1992).

Table 2—Conservation Reserve Program reimbursements in Arkansas, Mississippi, and Louisiana per acre; total cost share is for establishment costs, reimbursed at the rate of 50 percent of expenses for 303 stems per acre

	Arkansas	Louisiana	Mississippi
	Dollars		
Site preparation	21.00	10.00	16.00
Planting	.20/seedling		70.00
Seedling material		.26/seedling	
Herbicide		22.00	
Total cost-share reimbursement for establishment	40.80	55.39	43.00
Annual soil payment	35.00	45.00	44.00

RESULTS

Base Case

Afforestation with cottonwood appears to be profitable under most conditions (tables 3, 4, 5). The combination of low productivity Sharkey soil, stumpage at $8 per green ton and higher land taxes in Arkansas, however, result in negative NPVs (table 5). When the real interest rate of 4 percent is doubled to account for risk, even the moderately productive Tunica-Bowdre soils have negative NPV when stumpage is low (tables 3, 4, 5). Internal rates of return for Sharkey soil with medium stumpage level range from 6.32 percent in Arkansas (highest taxes) to 7.75 percent in Louisiana (lowest taxes).

Interplanting is included as an expense. Under most conditions of low productivity (Sharkey or Tunica-Bowdre soils), low to mid stumpage ($8-$10 per ton), high taxes (Arkansas), or combinations, including interplanting lowers NPV to negative values. Including cost share payments under the CRP makes NPV positive under all the conditions we assumed (data not shown). Cost share payments were assumed to be made for 9 of the 11 years of the rotation (no payments made in year 0 when site preparation occurs, or in harvest year) and totaled more than the costs accrued under the base case (no inflation or risk adjustment).

Table 3—Net present value of afforestation scenarios in Arkansas by soil/productivity class, values are without cost-share incentives from CRP

	Values								
	Sharkey			Tunica-Bowdre			Commerce		
Stumpage	8	10	12	8	10	12	8	10	12
	Dollars								
Base	(8)	46	101	34	100	165	130	219	308
Base, risk adjustment (4%)	(62)	(26)	10	(34)	10	53	29	88	147
Base + interplant	(56)	(1)	53	(13)	52	117	82	171	260
Inflate 3%	55	129	202	112	200	288	240	360	480
Inflate 3%, interplant	3	76	150	60	148	236	188	308	428
Inflate costs 3%, stumpage 5%	117	206	295	187	293	399	342	487	632
Inflate costs 3%, stumpage 5%, and interplant	65	154	243	135	241	347	290	435	580

Table 4—Net present value of afforestation scenarios in Louisiana by soil/productivity class, values are without cost-share incentives from CRP

	Values								
	Sharkey			Tunica-Bowdre			Commerce		
Stumpage	8	10	12	8	10	12	8	10	12
	Dollars								
Base	19	73	128	61	126	192	156	245	335
Base, risk adjustment (4%)	(40)	(4)	32	(12)	31	74	51	110	169
Base + interplant	(29)	26	80	13	79	144	109	198	287
Inflate 3%	86	159	233	143	231	319	271	391	511
Inflate 3%, interplant	34	107	181	91	179	267	219	339	459
Inflate costs 3%, stumpage 5%	150	239	328	219	326	432	374	519	664
Inflate costs 3%, stumpage 5%, and interplant	96	185	274	166	272	378	321	466	611

Table 5—Net present value of afforestation scenarios in Mississippi by soil/productivity class, values are without cost-share incentives from CRP

	Values								
	Sharkey			Tunica-Bowdre			Commerce		
Stumpage	8	10	12	8	10	12	8	10	12
	Dollars								
Base	15	70	124	58	123	188	153	242	331
Base, risk adjustment (4%)	(43)	(7)	30	(15)	29	72	48	107	166
Base + interplant	(33)	22	77	10	75	141	105	194	284
Inflate 3%	82	155	229	139	227	315	267	387	507
Inflate 3%, interplant	30	103	177	87	175	263	215	335	455
Inflate costs 3%, stumpage 5%	144	233	322	214	320	426	369	514	659
Inflate costs 3%, stumpage 5%, and interplant	92	181	270	162	268	374	317	462	607

Inflation Scenarios

Inflating costs and stumpage without changing the discount rate made all scenarios profitable (tables 3, 4, 5). Actual stumpage yields increased 34 percent when inflated at 3 percent annually, and increased 63 percent when inflated at 5 percent annually. The effect on NPV depended upon productivity, with a proportionally greater increase on the lower productivity Sharkey soil. For example, in Louisiana when stumpage is based on the initial rate of $10 per green ton, the percentage increase in NPV for Sharkey is 118 percent for 3 percent inflation and 227 percent for 5 percent inflation. On the higher productivity Commerce soil, the NPV increases are 60 percent and 112 percent for the 3 and 5 percent inflation factors, respectively.

Long-Term Timber Management

After the initial afforestation of agricultural land, the landowner interested in long-term timber management is faced with the decision of whether to include coppice rotations. The results of the three scenarios we evaluated are shown by State and soil series in tables 6, 7, 8. The high cost of site preparation of a cutover forest stand, as compared to afforestation of bare agricultural land, greatly affects profitability. On the low productivity Sharkey soil (tables 6, 7, 8), positive BLV is obtained only when stumpage is high or coppice rotations are included. Even when inflation is included, the highest BLV occurs when management is alternating clearcut and plant with coppice (data not shown).

On the medium productivity Tunica-Bowdre soils, alternating clear and plant with coppice produces positive BLV even at the lowest stumpage rate. If costs and stumpage are inflated 3 percent annually, the highest BLV are still produced by alternating clearcutting with coppice. If stumpage is inflated at 5 percent annually, the highest BLV is obtained with just one coppice rotation following afforestation.

The higher productivity Commerce soils can be managed profitably with the most intensive practices (tables 6, 7, 8) but the choice of management regime with the highest BLV is sensitive to stumpage prices. At the highest stumpage rate, there is little difference in BLV between management regimes. At the highest inflation rate (5 percent), the most intensive regime (clearcut and plant every rotation) produces the highest BLV.

DISCUSSION

Under most conditions, it is profitable to afforest with cottonwood. Stumpage, volume yields, and taxes all influence profitability in the short and long-terms. Cost share programs such as the CRP, considerably enhance profitability, especially on lower productivity sites. Cost share can offset risk as well as provide an annual income. A landowner interested in afforestation primarily for wildlife should consider interplanting cottonwood and oak; the yield from one cottonwood pulpwood rotation can offset the costs of afforestation even without cost share.

Long-term timber management for pulpwood can be profitable if coppice is included. On lower productivity sites, coppice is probably necessary. A landowner has more options, however, on the higher productivity sites. Sawtimber management is a possibility although Anderson and Krinard (1985) were not optimistic unless real stumpage increased. Profitability could be increased by increasing the merchantable yield of coppice. Lowering the cost of site preparation on cutover land would probably do the most to increase attractiveness of converting agricultural land to timber management. Two potential developments that may increase profitability are new herbicides that can be applied during the growing season or transgenic clones with herbicide tolerance. In either case, mechanical cultivation for weed control would no longer be necessary, and expensive site preparation could be avoided.

Two potential sources of income were omitted from our analysis. Annual payments for hunting leases could more than offset annual costs for taxes and administration. Fee hunting leases for forest land in the "delta" area of northwest Mississippi average approximately $5 to $7 per acre per year (Personal communication. Stephen C. Grado. 1999. Assistant Professor of Forest Economics, Mississippi State University, P.O. Box 9681, Mississippi State, MS 39762).

Table 6—Bare land value (BLV) for long-term timber management scenarios in Arkansas by soil productivity classes, values are for the base case with no inflation in cost or stumpage

	Values								
	Sharkey			Tunica-Bowdre			Commerce		
Stumpage	8	10	12	8	10	12	8	10	12
	Dollars								
Clear and plant	(294)	(138)	18	(173)	14	200	99	354	608
Coppice once	(162)	(22)	119	(53)	115	282	190	418	646
Alternate coppice and clear and plant	(70)	59	188	30	184	338	252	462	671

Table 7—Bare land value (BLV) for long-term timber management scenarios in Louisiana by soil productivity classes, values are for the base case with no inflation in cost or stumpage

	Values								
	Sharkey			Tunica-Bowdre			Commerce		
Stumpage	8	10	12	8	10	12	8	10	12
	Dollars								
Clear and plant	(218)	(62)	94	(97)	90	276	175	430	684
Coppice once	(85)	55	195	24	191	359	266	494	722
Alternate coppice and clear and plant	7	136	265	107	261	415	329	538	747

Payments for carbon sequestration have been made in the Tropics, in anticipation of a market for trading carbon credits by industries that produce greenhouse gases (Amacher and others 1997).

ACKNOWLEDGMENTS

We would like to thank Pat Weber, Jim Shepard, and Chip Morgan for stimulating the initiation of this work. Discussions with landowners kept us coming back to the central question, "If this is such a great idea why isn't everyone planting trees?" More distant (in time and space) influences on this work were David Allee and Lloyd Irland, who convinced JAS that the proper starting point of economic analysis is the assumption that individual behavior is rational. We thank Steve Grado, Emile Gardiner, Mark Coleman, and David Groberg for helpful reviews.

Table 8—Bare land value (BLV) for long-term timber management scenarios in Mississippi by soil productivity classes, values are for the base case with no inflation in cost or stumpage

	Values								
	Sharkey			Tunica-Bowdre			Commerce		
Stumpage	8	10	12	8	10	12	8	10	12
	Dollars								
Clear and plant	(228)	(72)	84	(106)	80	266	166	420	674
Coppice once	(95)	45	185	14	181	349	257	485	713
Alternate coppice and clear and plant	(3)	126	255	97	251	405	319	528	738

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